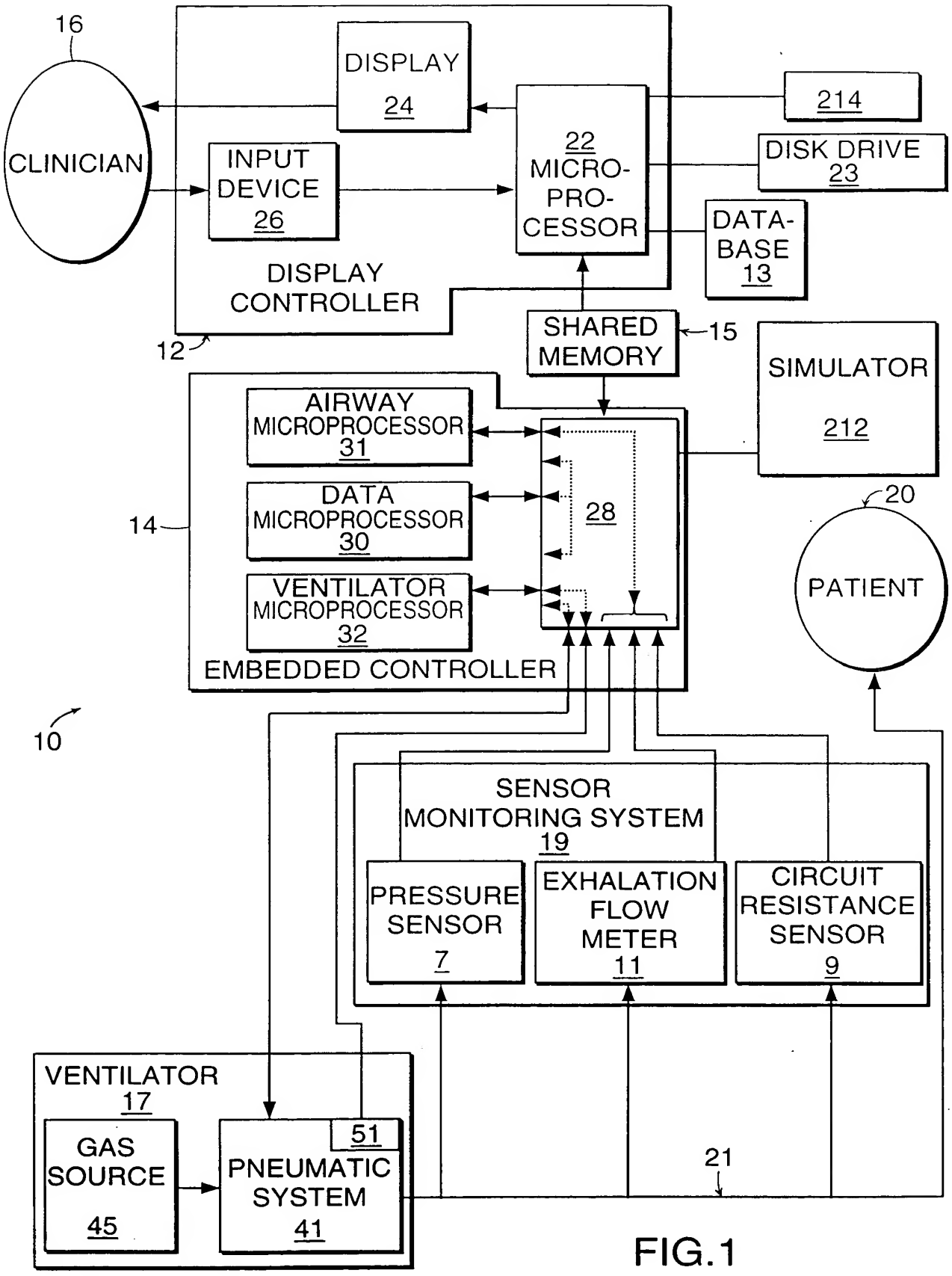
16
CLINICIAN
DISPLAY
24
INPUT
DEVICE
26
22
MICRO-
PRO-
CESSOR
214
DISK DRIVE
23
DATA-
BASE
13
DISPLAY
CONTROLLER
12
SHARED
MEMORY
15
SIMULATOR
212
AIRWAY
MICROPROCESSOR
31
DATA
MICROPROCESSOR
30
VENTILATOR
MICROPROCESSOR
32
28
14
EMBEDDED CONTROLLER
20
PATIENT
10
SENSOR
MONITORING SYSTEM
19
PRESSURE
SENSOR
7
EXHALATION
FLOW
METER
11
CIRCUIT
RESISTANCE
SENSOR
9
VENTILATOR
17
GAS
SOURCE
45
51
PNEUMATIC
SYSTEM
41
21

FIG.1

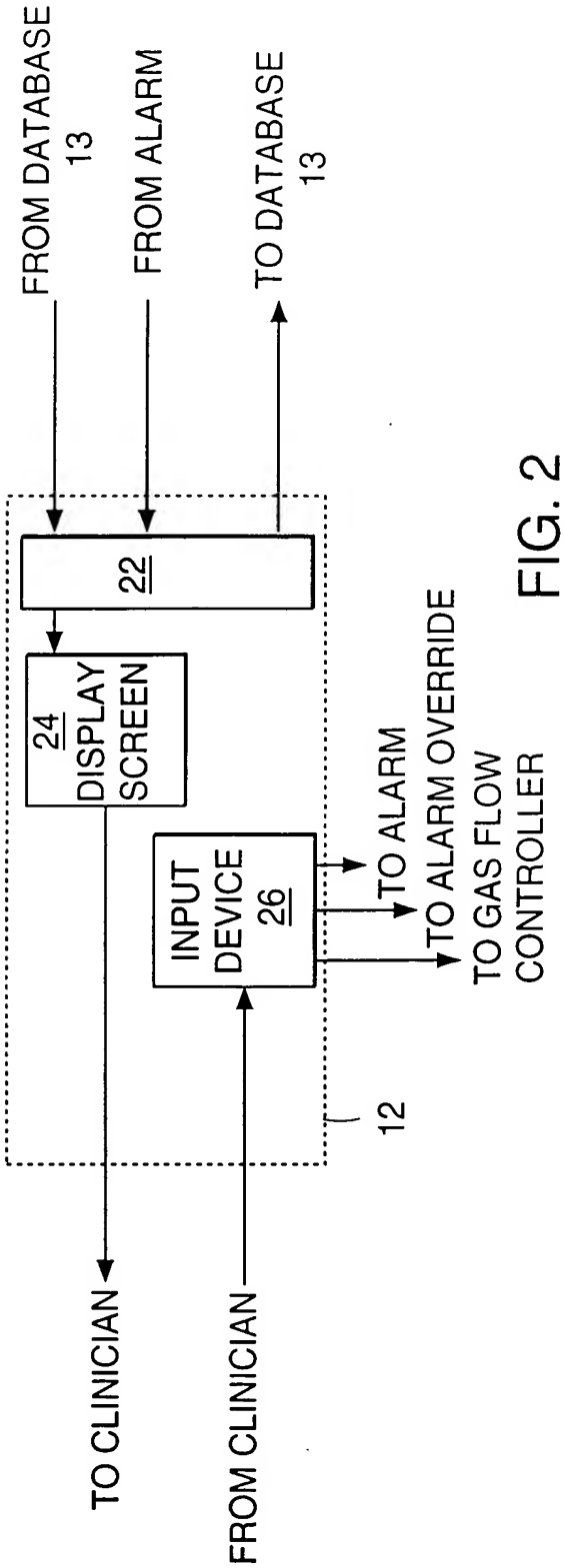
FROM DATABASE 13
FROM ALARM
TO DATABASE 13
22
24 DISPLAY SCREEN
INPUT DEVICE 26
TO ALARM
TO ALARM OVERRIDE
TO GAS FLOW CONTROLLER
12
TO CLINICIAN
FROM CLINICIAN

FIG. 2

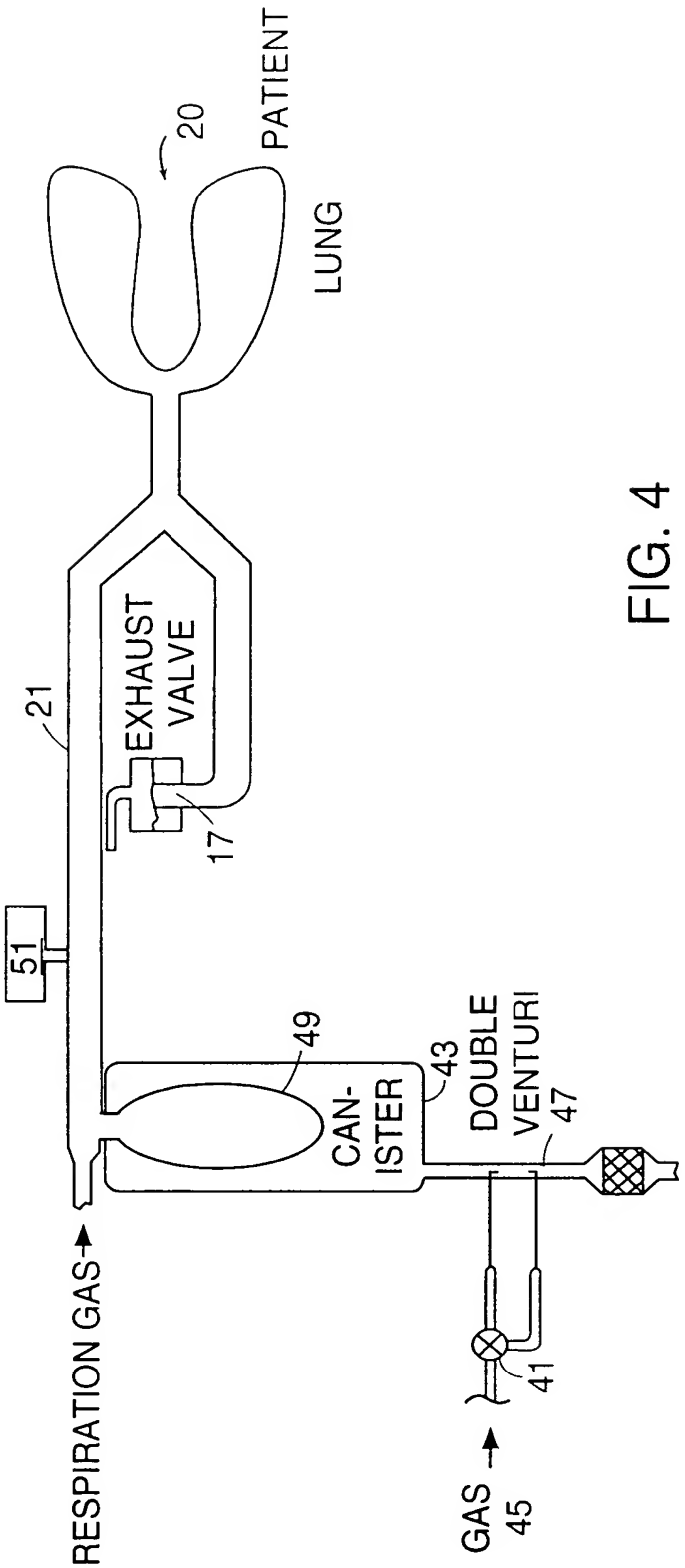
20
PATIENT LUNG
21
EXHAUST VALVE
17
51
49
43
CAN-ISTER
DOUBLE VENTURI
47
RESPIRATION GAS
41
GAS 45

FIG. 4

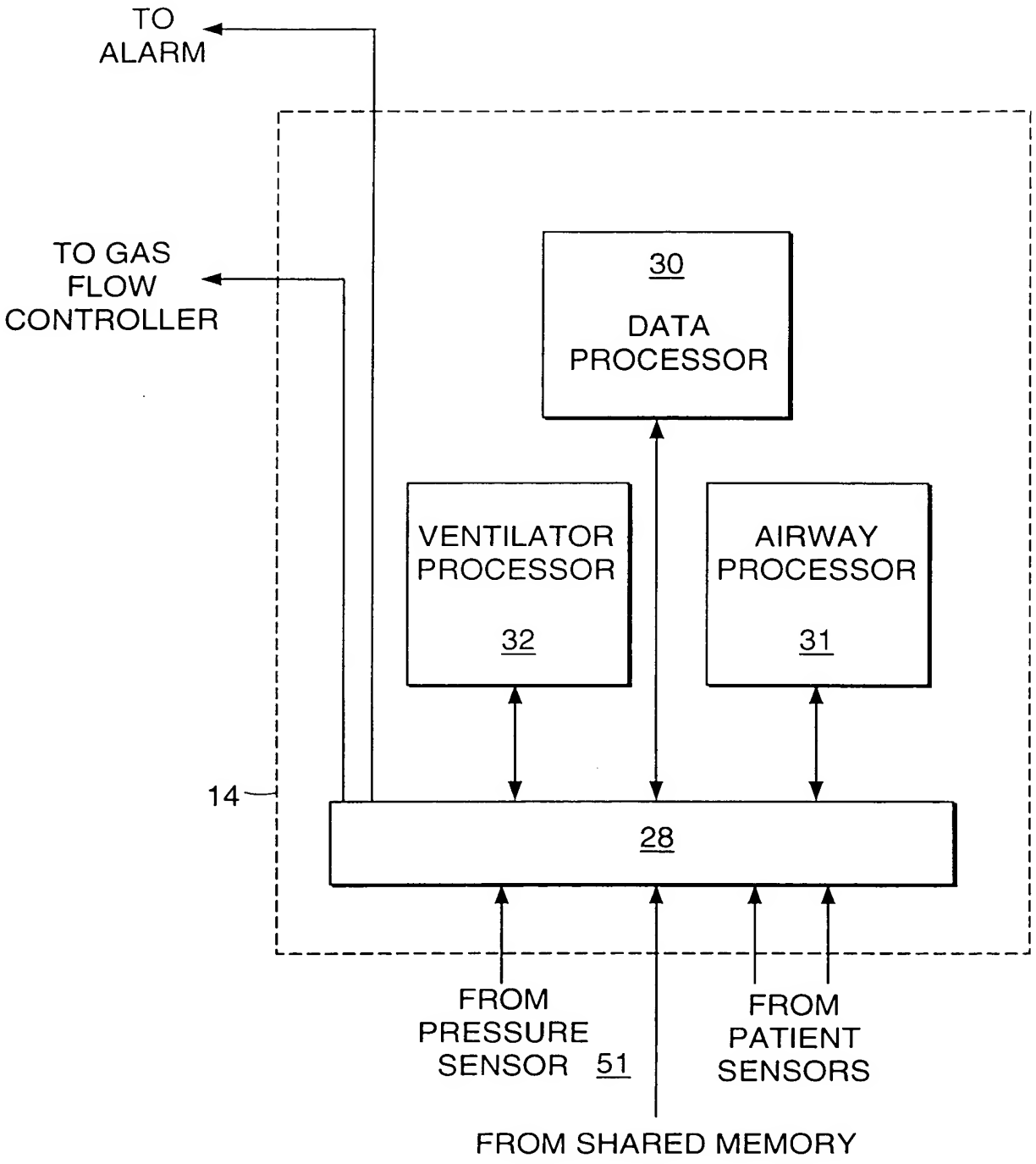
TO ALARM
TO GAS FLOW CONTROLLER
30
DATA PROCESSOR
VENTILATOR PROCESSOR
32
AIRWAY PROCESSOR
31
14
28
FROM PRESSURE SENSOR 51
FROM PATIENT SENSORS
FROM SHARED MEMORY

FIG. 3

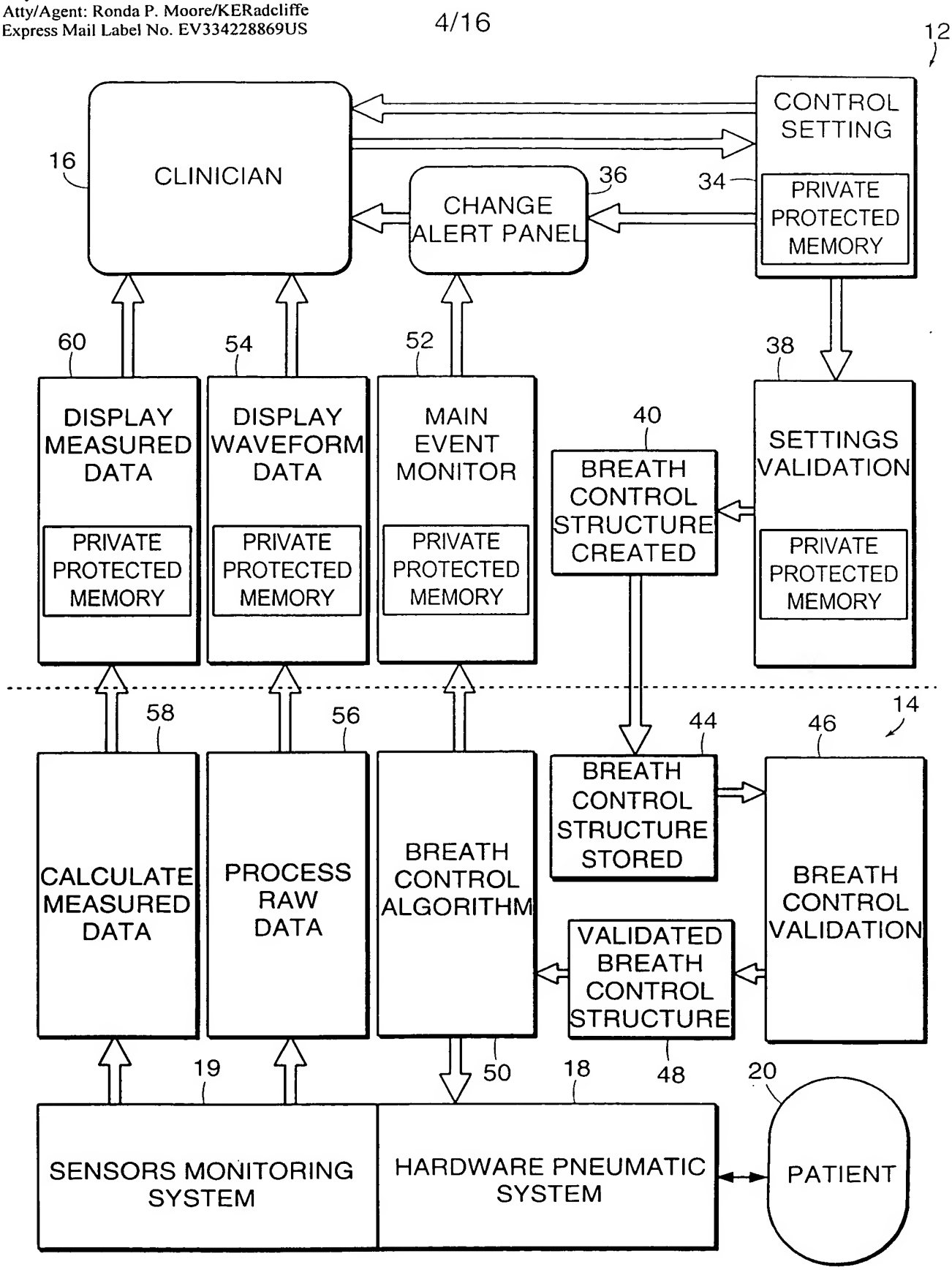
12
CONTROL SETTING
16
CLINICIAN
36
34
CHANGE ALERT PANEL
PRIVATE PROTECTED MEMORY
60
54
52
38
DISPLAY MEASURED DATA
DISPLAY WAVEFORM DATA
MAIN EVENT MONITOR
40
SETTINGS VALIDATION
BREATH CONTROL STRUCTURE CREATED
PRIVATE PROTECTED MEMORY
PRIVATE PROTECTED MEMORY
PRIVATE PROTECTED MEMORY
PRIVATE PROTECTED MEMORY
58
56
44
46
14
CALCULATE MEASURED DATA
PROCESS RAW DATA
BREATH CONTROL ALGORITHM
BREATH CONTROL STRUCTURE STORED
BREATH CONTROL VALIDATION
VALIDATED BREATH CONTROL STRUCTURE
19
50
18
48
20
SENSORS MONITORING SYSTEM
HARDWARE PNEUMATIC SYSTEM
PATIENT

FIG. 5

```
IF ((FLOW SLOPE INCREASING)                                    (STEP 300)
AND (PRESSURE SLOPE DECREASING)
   THEN (ADD INHALED VOLUME TO
   TO EVENT VOLUME = (VOLUME - BASELINE))
        ELSE (ADD (0) TO EVENT
        VOLUME = (VOLUME-BASELINE))

IF (EVENT VOLUME > TRIGGER VOLUME)                             (STEP 310)
   THEN (TRIGGER FLAG = YES)

IF (TRIGGER FLAG = YES)                                        (STEP 320)
   THEN ((IF TIME > 200mSEC) THEN (TRIGGER FLAG = NO)
        ELSE (ADD TO VOLUME = (VOLUME - BASELINE)))

IF (VOLUME > TRIGGER VOLUME)        (STEP 330)
   THEN (INITIATE BREATH))
        ELSE (DO NOT INITIATE BREATH)
```

FIG. 6

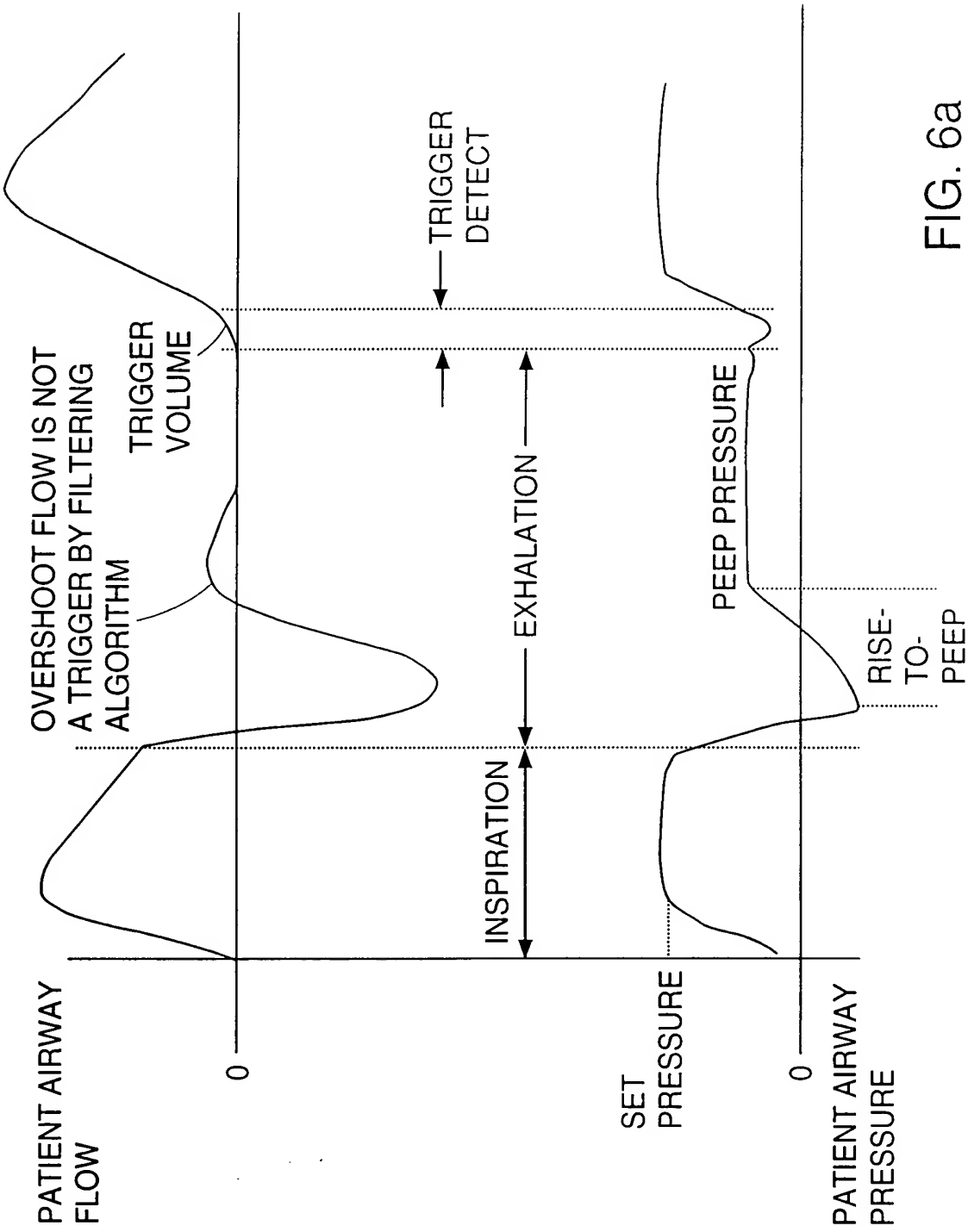
PATIENT AIRWAY FLOW
0
OVERSHOOT FLOW IS NOT A TRIGGER BY FILTERING ALGORITHM
TRIGGER VOLUME
TRIGGER DETECT
INSPIRATION
EXHALATION
SET PRESSURE
PEEP PRESSURE
RISE-TO-PEEP
0
PATIENT AIRWAY PRESSURE

FIG. 6a

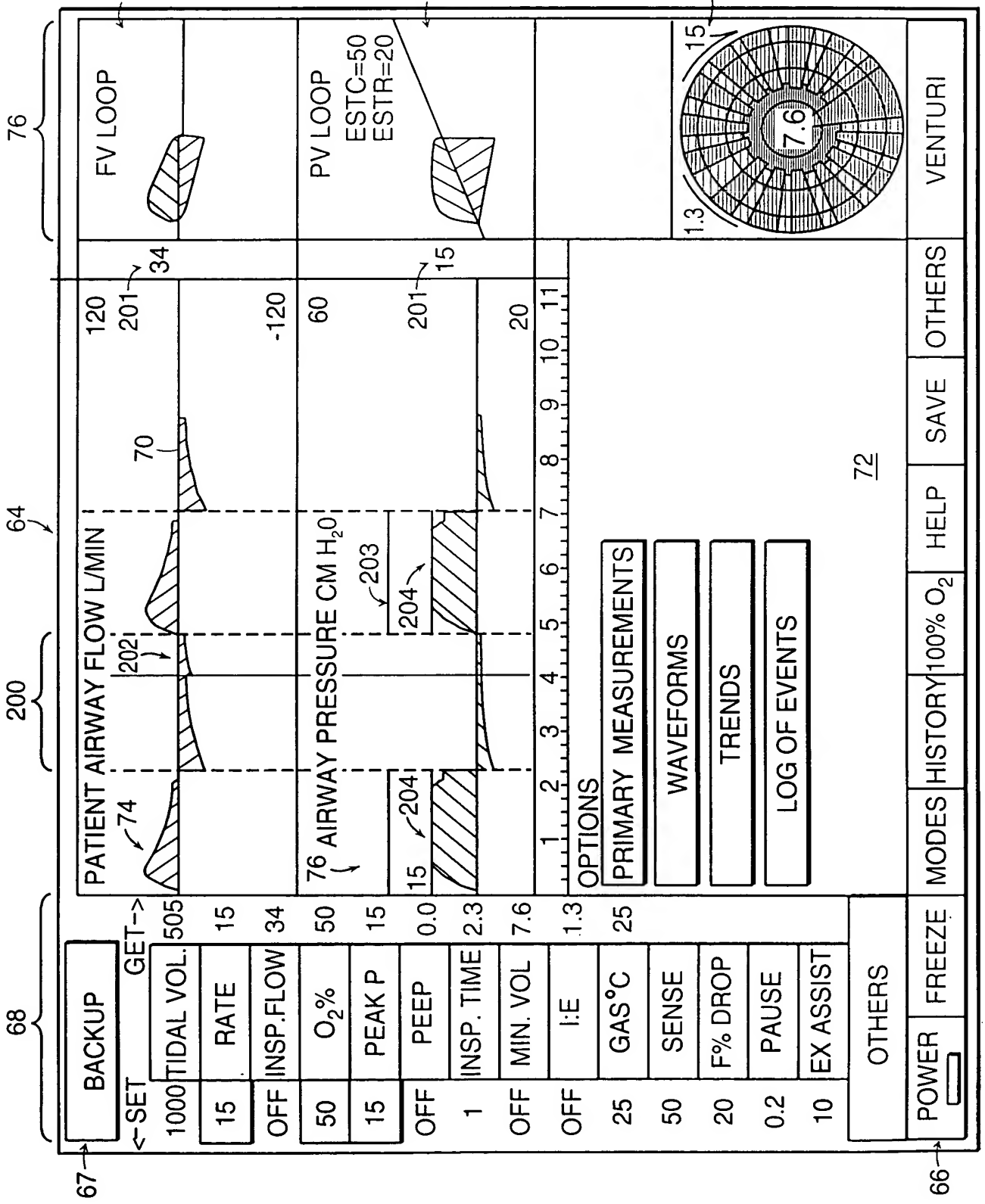
67
66
68
64
200
76
78
80
82'
72
BACKUP
SET
GET->
TIDAL VOL.
RATE
INSP.FLOW
O_2%
PEAK P
PEEP
INSP. TIME
MIN. VOL
I:E
GAS°C
SENSE
F% DROP
PAUSE
EX ASSIST
OTHERS
POWER
FREEZE
PATIENT AIRWAY FLOW L/MIN
AIRWAY PRESSURE CM H_2O
FV LOOP
PV LOOP
ESTC=50
ESTR=20
OPTIONS
PRIMARY MEASUREMENTS
WAVEFORMS
TRENDS
LOG OF EVENTS
MODES
HISTORY
100% O_2
HELP
SAVE
OTHERS
VENTURI

FIG. 7

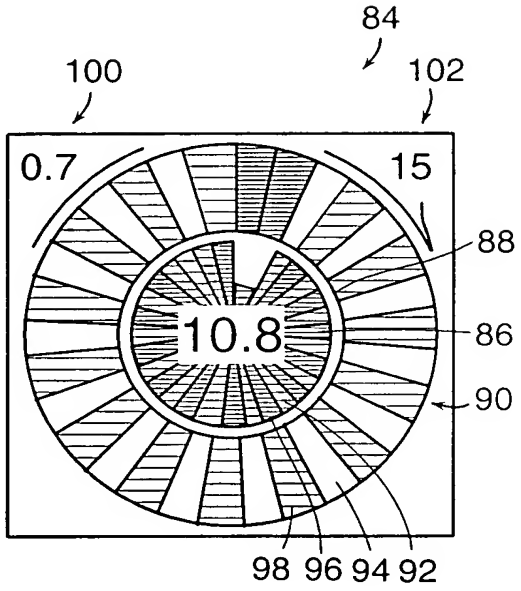

FIG.8

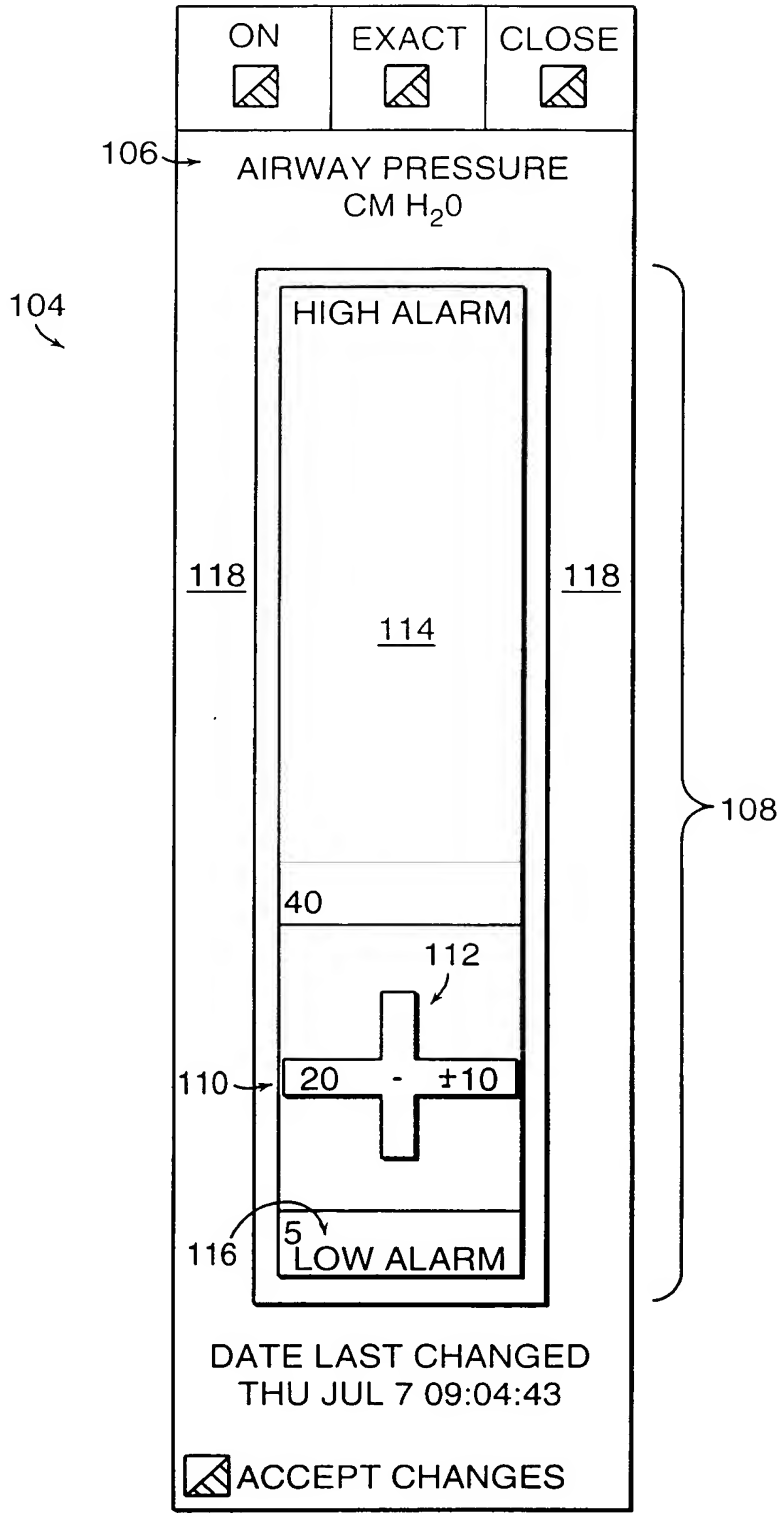
ON
EXACT
CLOSE
106
AIRWAY PRESSURE
CM H_2O
104
HIGH ALARM
118
118
114
108
40
112
110
20 - ±10
116
5
LOW ALARM
DATE LAST CHANGED
THU JUL 7 09:04:43
ACCEPT CHANGES

FIG. 9

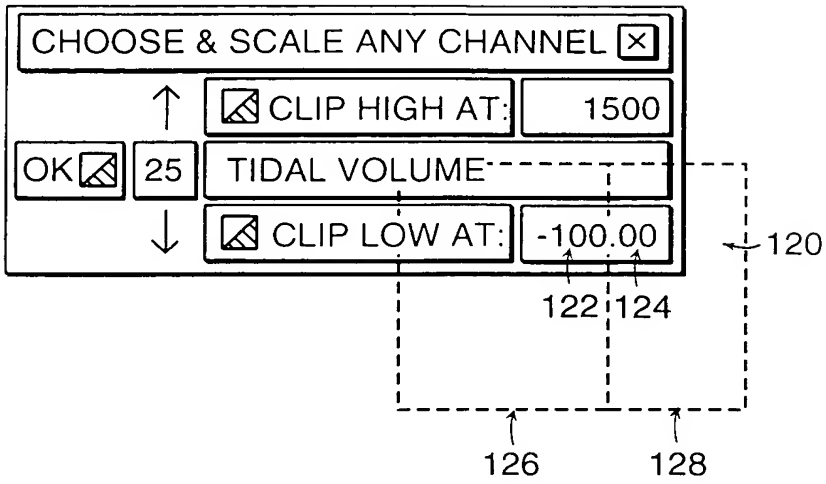
CHOOSE & SCALE ANY CHANNEL
CLIP HIGH AT:
1500
OK
25
TIDAL VOLUME
CLIP LOW AT:
-100.00
120
122
124
126
128

FIG. 10

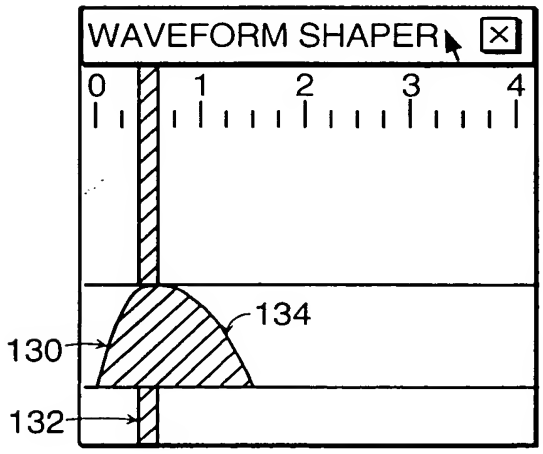
WAVEFORM SHAPER
0
1
2
3
4
134
130
132

FIG. 15

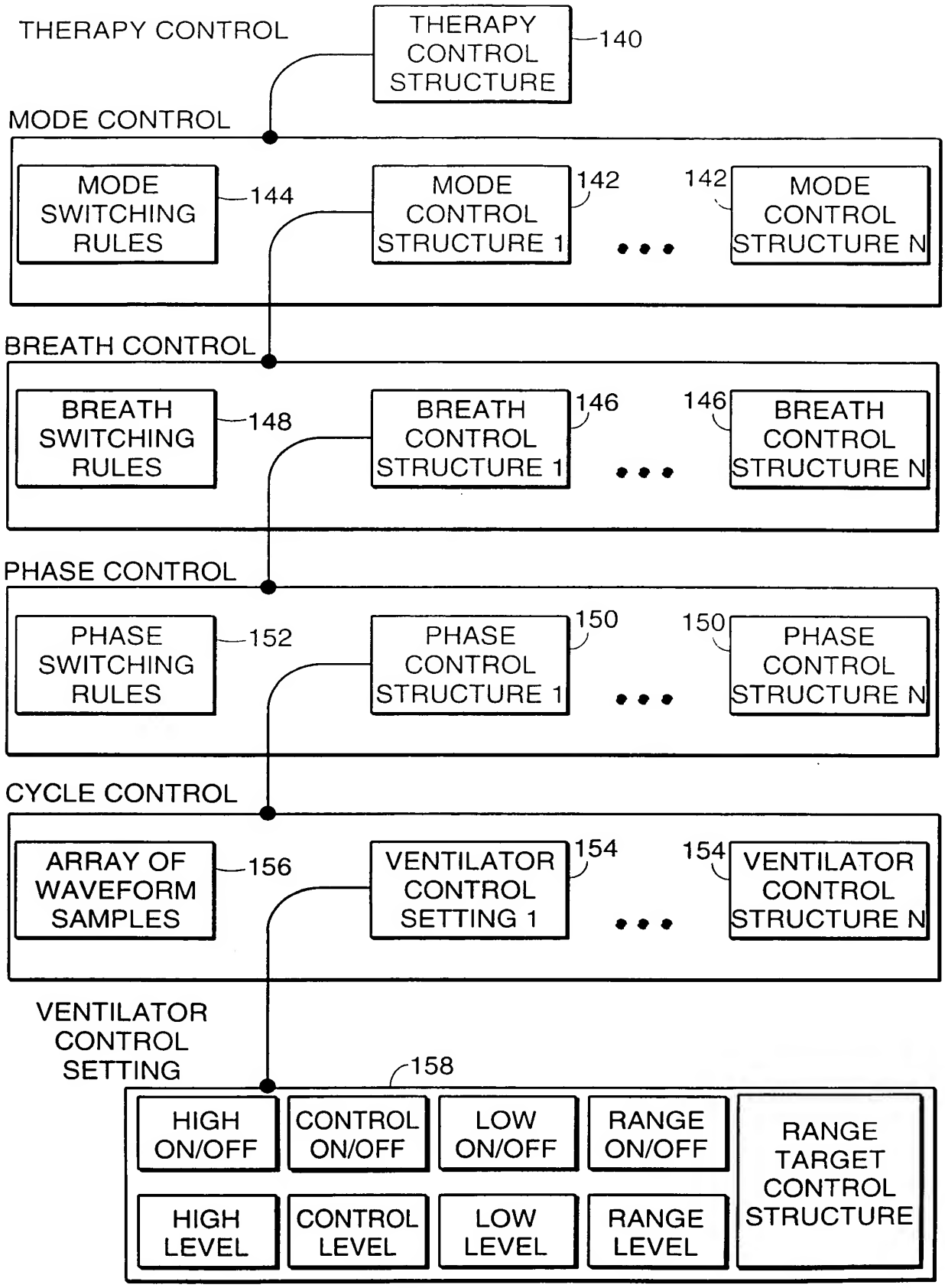
THERAPY CONTROL
THERAPY CONTROL STRUCTURE
140
MODE CONTROL
MODE SWITCHING RULES
144
MODE CONTROL STRUCTURE 1
142
MODE CONTROL STRUCTURE N
142
BREATH CONTROL
BREATH SWITCHING RULES
148
BREATH CONTROL STRUCTURE 1
146
BREATH CONTROL STRUCTURE N
146
PHASE CONTROL
PHASE SWITCHING RULES
152
PHASE CONTROL STRUCTURE 1
150
PHASE CONTROL STRUCTURE N
150
CYCLE CONTROL
ARRAY OF WAVEFORM SAMPLES
156
VENTILATOR CONTROL SETTING 1
154
VENTILATOR CONTROL STRUCTURE N
154
VENTILATOR CONTROL SETTING
158
HIGH ON/OFF
CONTROL ON/OFF
LOW ON/OFF
RANGE ON/OFF
RANGE TARGET CONTROL STRUCTURE
HIGH LEVEL
CONTROL LEVEL
LOW LEVEL
RANGE LEVEL

FIG. 11

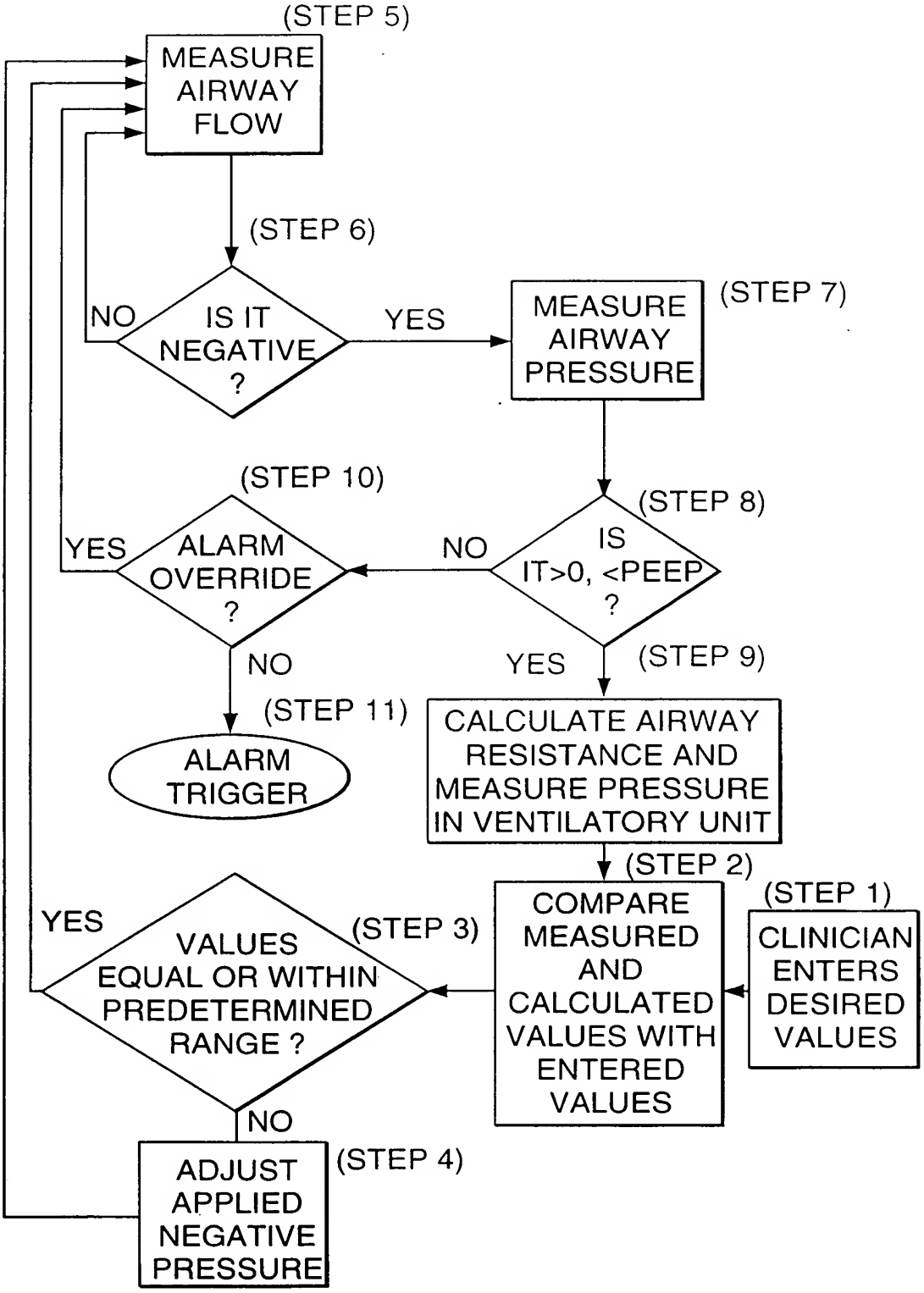
(STEP 5)
MEASURE AIRWAY FLOW
(STEP 6)
IS IT NEGATIVE ?
NO
YES
MEASURE AIRWAY PRESSURE
(STEP 7)
(STEP 8)
IS IT>0, <PEEP ?
NO
YES
(STEP 10)
ALARM OVERRIDE ?
YES
NO
(STEP 11)
ALARM TRIGGER
(STEP 9)
CALCULATE AIRWAY RESISTANCE AND MEASURE PRESSURE IN VENTILATORY UNIT
(STEP 2)
COMPARE MEASURED AND CALCULATED VALUES WITH ENTERED VALUES
(STEP 1)
CLINICIAN ENTERS DESIRED VALUES
(STEP 3)
VALUES EQUAL OR WITHIN PREDETERMINED RANGE ?
YES
NO
(STEP 4)
ADJUST APPLIED NEGATIVE PRESSURE

FIG. 12

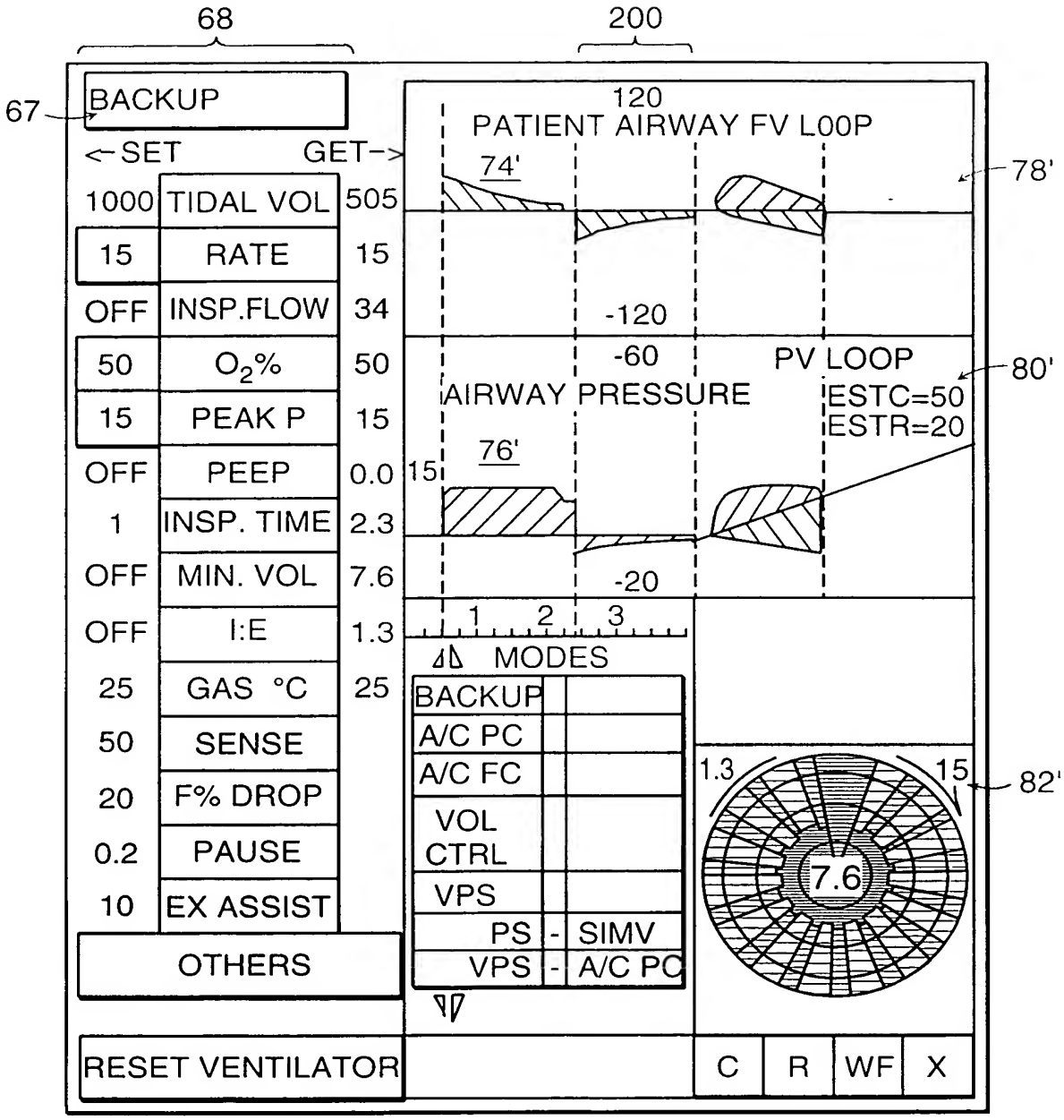
68
200
67
BACKUP
<-SET
GET->
1000 TIDAL VOL 505
15 RATE 15
OFF INSP.FLOW 34
50 O_2% 50
15 PEAK P 15
OFF PEEP 0.0
1 INSP. TIME 2.3
OFF MIN. VOL 7.6
OFF I:E 1.3
25 GAS °C 25
50 SENSE
20 F% DROP
0.2 PAUSE
10 EX ASSIST
OTHERS
RESET VENTILATOR
120
PATIENT AIRWAY FV LOOP
74'
78'
-120
-60
PV LOOP
80'
AIRWAY PRESSURE
ESTC=50
ESTR=20
76'
15
-20
1 2 3
MODES
BACKUP
A/C PC
A/C FC
VOL CTRL
VPS
PS - SIMV
VPS - A/C PC
1.3
15
82'
7.6
C
R
WF
X

FIG. 13

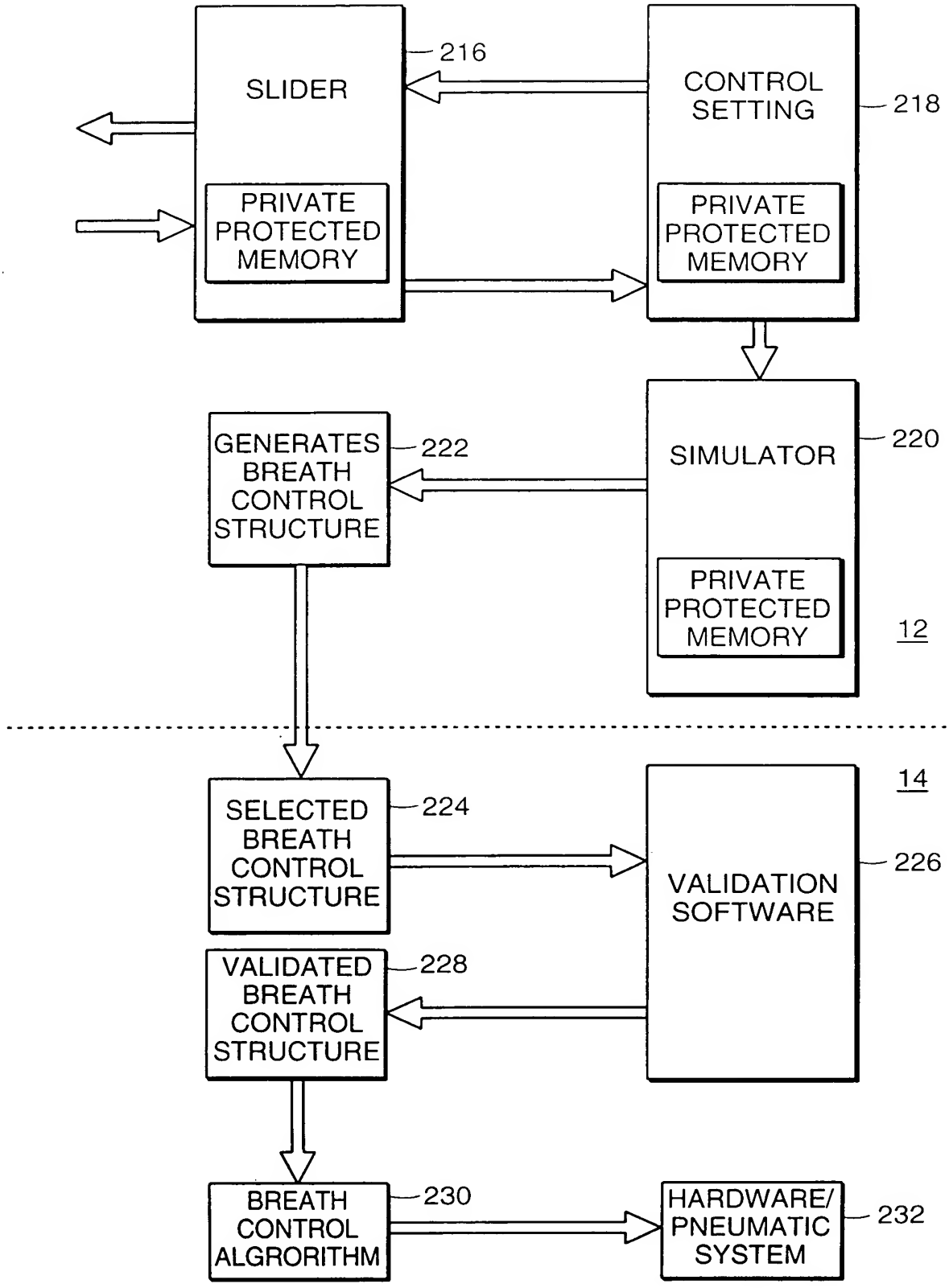
SLIDER
216
CONTROL SETTING
218
PRIVATE PROTECTED MEMORY
PRIVATE PROTECTED MEMORY
GENERATES BREATH CONTROL STRUCTURE
222
SIMULATOR
220
PRIVATE PROTECTED MEMORY
12
14
SELECTED BREATH CONTROL STRUCTURE
224
VALIDATION SOFTWARE
226
VALIDATED BREATH CONTROL STRUCTURE
228
BREATH CONTROL ALGRORITHM
230
HARDWARE/ PNEUMATIC SYSTEM
232

FIG. 14

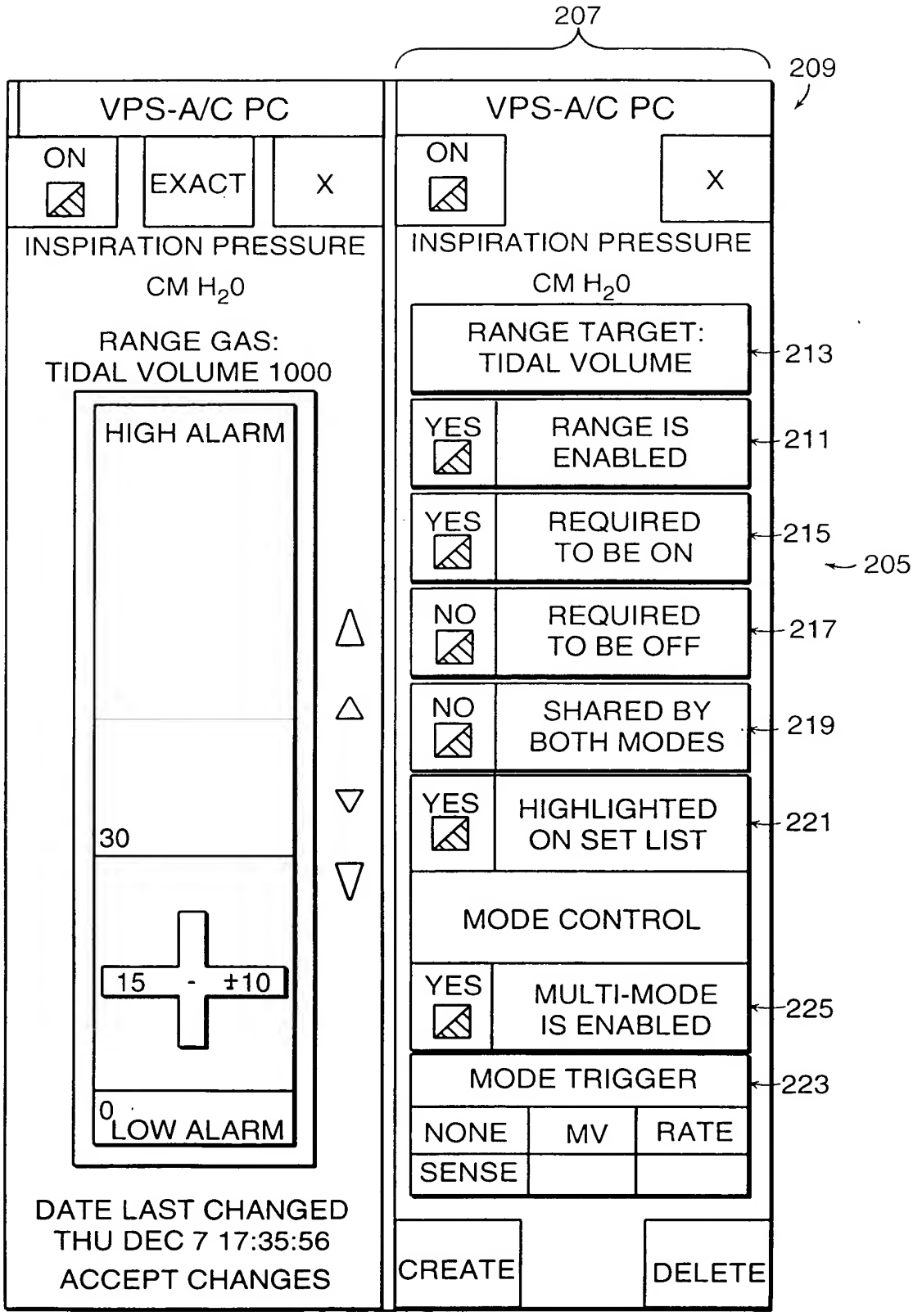
207
209
VPS-A/C PC
ON
EXACT
X
INSPIRATION PRESSURE
CM H_2O
RANGE GAS:
TIDAL VOLUME 1000
HIGH ALARM
30
15 - ±10
0
LOW ALARM
DATE LAST CHANGED
THU DEC 7 17:35:56
ACCEPT CHANGES
VPS-A/C PC
ON
X
INSPIRATION PRESSURE
CM H_2O
RANGE TARGET: TIDAL VOLUME
213
YES
RANGE IS ENABLED
211
YES
REQUIRED TO BE ON
215
205
NO
REQUIRED TO BE OFF
217
NO
SHARED BY BOTH MODES
219
YES
HIGHLIGHTED ON SET LIST
221
MODE CONTROL
YES
MULTI-MODE IS ENABLED
225
MODE TRIGGER
223
NONE
MV
RATE
SENSE
CREATE
DELETE

FIG.16

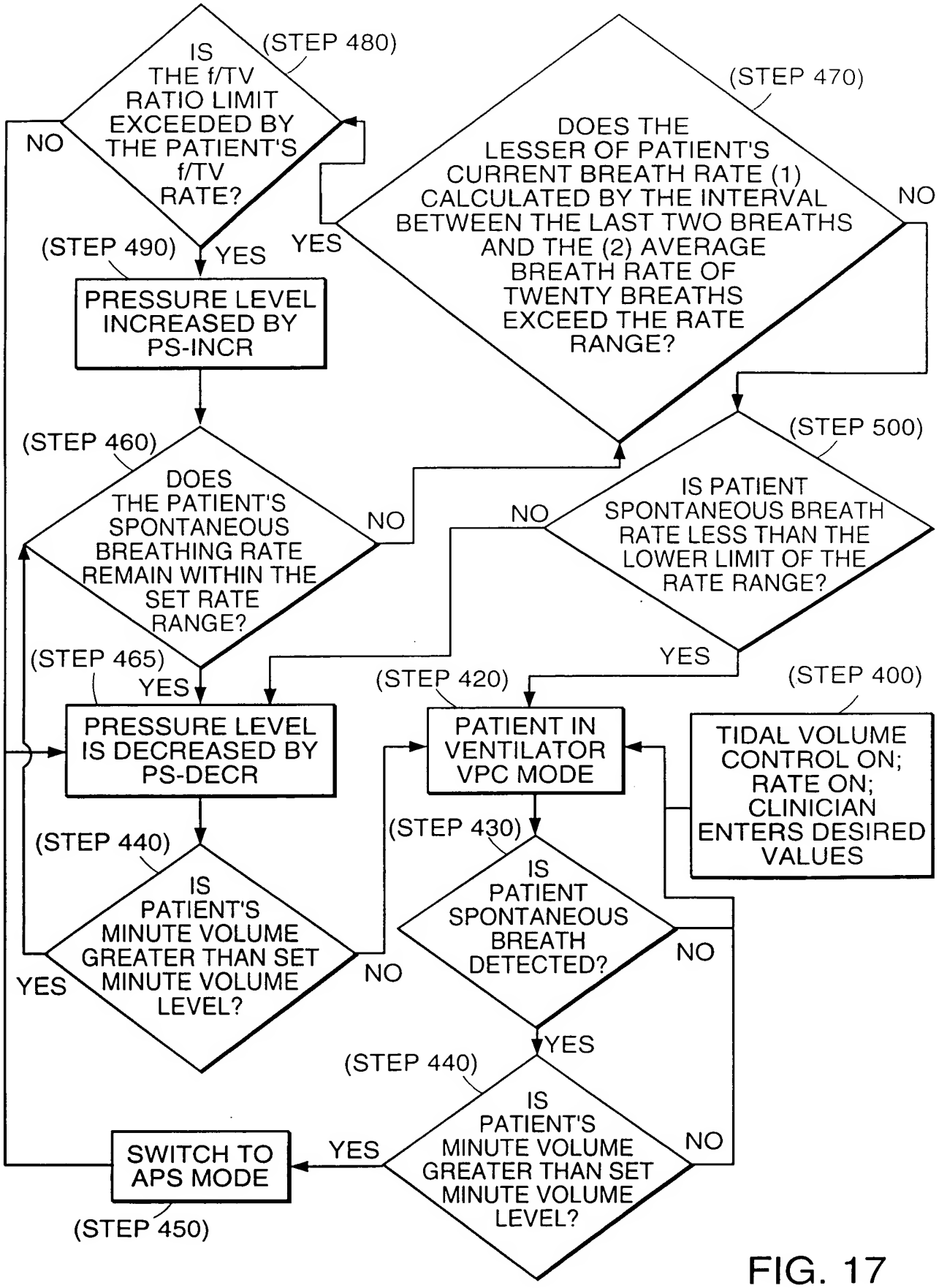
(STEP 480)
IS THE f/TV RATIO LIMIT EXCEEDED BY THE PATIENT'S f/TV RATE?
NO
YES
(STEP 490)
PRESSURE LEVEL INCREASED BY PS-INCR
(STEP 470)
DOES THE LESSER OF PATIENT'S CURRENT BREATH RATE (1) CALCULATED BY THE INTERVAL BETWEEN THE LAST TWO BREATHS AND THE (2) AVERAGE BREATH RATE OF TWENTY BREATHS EXCEED THE RATE RANGE?
YES
NO
(STEP 460)
DOES THE PATIENT'S SPONTANEOUS BREATHING RATE REMAIN WITHIN THE SET RATE RANGE?
NO
(STEP 500)
IS PATIENT SPONTANEOUS BREATH RATE LESS THAN THE LOWER LIMIT OF THE RATE RANGE?
NO
YES
(STEP 465)
YES
PRESSURE LEVEL IS DECREASED BY PS-DECR
(STEP 420)
PATIENT IN VENTILATOR VPC MODE
(STEP 400)
TIDAL VOLUME CONTROL ON; RATE ON; CLINICIAN ENTERS DESIRED VALUES
(STEP 440)
IS PATIENT'S MINUTE VOLUME GREATER THAN SET MINUTE VOLUME LEVEL?
YES
NO
(STEP 430)
IS PATIENT SPONTANEOUS BREATH DETECTED?
NO
YES
(STEP 440)
IS PATIENT'S MINUTE VOLUME GREATER THAN SET MINUTE VOLUME LEVEL?
NO
YES
SWITCH TO APS MODE
(STEP 450)

FIG. 17